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THE EFFECT OF MENTAL AND PHYSICAL PRACTICE ON THE LEARNING OF GROSS MOTOR SKILLS.

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THE PURPOSE OF THE STUDY WAS TO DETERMINE THE EFFECTS OF DIFFERENT SCHEDULES OF MENTAL AND PHYSICAL PRACTICE ON THE LEARNING AND RETENTION OF THREE MOTOR TASKS--USING THE PURSUIT ROTOR AND LEARNING THE SOCCER KICK, AND JUMP SHOT. THREE SEPARATE EXPERIMENTS WERE CONDUCTED IN THREE JUNIOR HIGH SCHOOLS USING 80, 72, AND 60 SEVENTH GRADE BOYS AS SUBJECTS. EACH EXPERIMENT INVOLVED FOUR GROUPS, EQUATED ON THE BASIS OF INITIAL PERFORMANCE SCORES IN THE PARTICULAR LEARNING TASK. EACH GROUP WAS ASSIGNED TO A DIFFERENT PRACTICE SCHEDULE FOR 7 SUCCESSIVE SCHOOL DAYS. THREE OF THE GROUPS FOLLOWED SCHEDULES WHICH INVOLVED BOTH MENTAL AND PHYSICAL PRACTICE IN DIFFERENT PROPORTIONS (75 PERCENT MENTAL-25 PERCENT PHYSICAL, 50 PERCENT MENTAL-50 PERCENT PHYSICAL, AND 25 PERCENT MENTAL-75 PERCENT PHYSICAL), AND ONE GROUP ENGAGED IN PHYSICAL PRACTICE ONLY. PERFORMANCE TESTS WERE ADMINISTERED TO ALL GROUPS AT THE END OF 7 DAYS AND AT THE END OF 3 WEEKS OF NO PRACTICE. THE CONCLUSIONS WERE--(1) A SCHEDULE COMBINING BOTH PHYSICAL AND MENTAL TRIALS CAN PROVE AS VALUABLE IN LEARNING A MOTOR TASK AS A SCHEDULE IN WHICH ALL TRIALS ARE PHYSICAL, (2) WITHIN THE INTELLIGENCE RANGES OF SUBJECTS USED IN THESE STUDIES, IQ SCORES WERE NOT INDICATIVE OF ONE'S ABILITY TO BENEFIT FROM MENTAL PRACTICE, (3) UP TO 50 PERCENT OF THE PRACTICE TIME (OR TRIALS) SPENT IN MENTAL PRACTICE CAN BE AS EFFECTIVE AS 100 PERCENT OF THE TIME SPENT IN PHYSICAL PRACTICE, AND (4) ALTHOUGH SUBJECTS RESPONDED FAVORABLY AND CONSCIENTIOUSLY TO THE SUGGESTION OF MENTAL REHEARSAL, SOME BECAME IMPATIENT WHEN THE TECHNIQUE WAS USED TO EXCESS, UP TO THREE-FOURTHS OF THE PRACTICE TIME. (PS)

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# The Effect of Mental and Physical Practice on the Learning of Gross Motor Skills*

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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The amount of learning in motor skills has generally been assumed to be a function of the length of time spent in the physical rehearsal or performance of the tasks. Therefore, in the teaching of sports skills, vocational tasks, typing, playing musical instruments, and numerous other school and nonschool activities, primary emphasis has been placed on the need for physical practice. The learner has been encouraged to perform the activity for a given period of time, or for a certain number of repetitions. Consequently, little attention has been devoted to the matter of related mental activity.

The emphasis upon physical performance, with a neglect of the associated mental processes, does not seem to take full advantage of man's intellectual abilities. Too often learners seem to go through the motions rather mechanically without much thought or kinesthetic awareness of the essential movement responses.

Some recent research evidence suggests that related intellectual activity can be a valuable aid to the learning of motor tasks. It appears, therefore, that if mental and physical practices were effectively combined, tasks might be learned more rapidly, and with a greater understanding of the proper performance techniques. In

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addition, the discovery of effective mental rehearsal techniques may enable learners, in effect, to practice at times when they are not able to actively perform the tasks. The implications of this are far reaching. For example, in many motor learning situations, the child must "wait his turn" before taking part in the activity. The wait is often long, especially when facilities and equipment are limited, or when classes are large. Skill in mental rehearsal could insure that learning take place during these periods of "idleness". At other times the learner might more effectively "review" the activity when he is not actually at a practice session. Also, skills learned by this technique may become more meaningful. This could lead to longer retention, and perhaps greater carry-over use by the learner.

## RELATED LITERATURE

The concept of mental rehearsal first came into focus with the work of Kohler (7) during the second and third decades of the 20th century. He devoted considerable attention to the matter of insight in the development of gestalt psychology. In his experiments with apes it became apparent that the animals were figuring out answers to problems without always resorting to physical trial and error. Tolman (12), another learning theorist, indicated that learning often results from implicit trial and error practice. He believed mental rehearsal to be an important ingredient in all types of learning.

In recent years research with mental rehearsal has been conducted with a variety of motor tasks. In addition, several methodological approaches have been tried in an effort to determine the most effective technique for promoting mental practice. One of the earliest

studies was done by Sacket (10) in 1935. In this experiment college women practiced a finger maze task. One group took part in the physical performance of the task while other groups were asked to "think through" the skill one, two, or three times. The author reported that such symbolic practice proved beneficial for the learning and retention of that task, though not as valuable as physical practice of the skill. She found also that a smaller number of mental rehearsals was relatively more beneficial than a greater number.

Vandell, Davis, and Clugston (15) had junior high school boys practice the skills of basketball free throws and dart throwing. Physical and mental practice groups showed almost identical improvement. Clark (2) and Start (11) also employed the basketball free throw in an investigation of the effectiveness of mental rehearsal. Both reported significant gains as a result of such practice. In Clark's study a physical practice group showed a slight advantage over a group using mental practice exclusively.

Egstrom (5) had college men learn a novel paddle ball type skill according to different combinations of physical and mental practice. His study supported the use of a schedule in which both overt practice and conceptualization were used. In recent years a diversity of motor tasks have been used in an effort to determine the role of mental rehearsal. In this endeavor, Twinning (14) employed a ring tossing skill, Wilson (18) a tennis drive, Rubin-Rabsen (9) a keyboard skill, Waterland (17) bowling, Corbin (3) a stick juggling task, Trussel (13) ball juggling, and Jones (6) used a new gymnastic stunt. Each of these experiments reported some advantage for mental practice or a combination of mental and physical practice.

After an extensive review of the literature on mental practice Richardson (8) concluded that "...the trend of most studies indicates that MP (mental practice) procedures are associated with improved performance on the task". He reported eleven studies in which significant positive findings were obtained. Seven other studies were included which showed a tendency in favor of mental practice while only three indicated negative results from this technique.

Several studies reported in the literature, including those by Egstrom (5), Corbin (3), Trussel (13), and Burns (1) indicate that certain combinations of physical and mental practice may be effective. However, there is no general consensus as to the most effective combination or percentage of time which should be devoted to each technique. In addition, several methods for instructing subjects in the use of mental rehearsal, or providing imagery cues, have been reported. Such techniques have included the use of hand-out instructional sheets to be read, teacher-led group or individual sessions, mental practice at the scene of the activity to be performed as well as in a classroom setting, and either formal and informal methods. At this time no particular method has been established as superior to all others.

## PURPOSE

The purpose of this study was to determine the effect of different schedules of mental and physical practice on the learning and retention of three motor tasks. Specifically, a determination of the relative effects of four practice schedules, three of which were made up of different proportions of mental and physical practice, and one

devoted to physical practice entirely, was sought.

It is readily admitted that precise controls on the type or intensity of mental practice cannot be established by this experimentor. However, a pragmatic approach is taken in regard to the effectiveness of this technique, i.e. do the instructions and the time provided result in measurable improvements in performance on the part of the subjects.

To accomplish the purposes of this study three separate experiments were conducted in three different Philadelphia junior high schools. Inasmuch as different learning tasks and different subjects were employed in each of the schools, the experiments will be described separately.

General Design

Each of the experiments involved four groups which were equated on the basis of initial performance scores in the particular learning task. Each group was then assigned to a different practice schedule for seven successive school days. Three of the groups were instructed to follow schedules which involved both mental and physical practice, while one group was instructed only to engage in physical (overt) practice. Following this seven-day training period a performance test was administered to all groups to determine which practice schedule proved most effective for the learning of the task. After a three week no-practice period another test was administered so that a comparison of the more permanent effects (retention) of these schedules could be made.

## EXPERIMENT # 1 (PURSUIT ROTOR)

### The Task

The pursuit rotor* was selected as the learning task for this particular experiment. This activity has several advantages for the conduct of motor learning research. It is a task of demonstrated reliability based on several decades of research. In addition, there are several experimental control advantages. For example, it is very unlikely that any of the subjects would have prior experience in this task, or that unauthorized practice could take place during the experimental period. Also, it has been demonstrated that subjects in the age range as those included in this study are well motivated (even eager) to take part in experiments involving this type of task.

In the performance of this task the subject stood in front of the apparatus which was placed on a 30-inch high table. He held the wooden handle of the hinged stylus in his preferred hand. When the turntable started moving he attempted to keep the metal end of the stylus

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*The apparatus used in this study was the Epicycloid Pursuit Rotor, manufactured by the Marietta Apparatus Company in Marietta, Ohio. The $14\frac{1}{2}$ x $14\frac{1}{2}$ x $6\frac{1}{2}$ inch apparatus encompasses a turntable which is 12 inches in diameter. Three-fourths inch from the edge of the turntable is the center of a metal dot or "target" which is one half inch in diameter and is inset so that it is level with the surface of the turntable. (a second dot which is designed to operate in an epicycloid path was covered over with black tape and was not used in this study.) A 12 inch hinged stylus was wired to the apparatus. During the experiment an electric clock was attached to the pursuit rotor so that when the end of the stylus was in contact with the target the clock ran. When contact was lost the clock stopped. In this experiment the turntable was wired to electric timers which automatically switched it on to run for 15 seconds and switched it off for 15 seconds. In addition, a small signal light was automatically switched on five seconds prior to the commencement of the movement so that the subject would be alerted.

in contact with the revolving target. The turntable moved in a counter-clockwise direction at a speed of 45 revolutions per minute for 15 seconds after which it was stationary for 15 seconds. The subject's score was the accumulated time in which the stylus was in contact with the revolving target during the 15-second work period. All practices and tests were completed in a well lighted (windowless) room in which only the experimentor and subject were present.

Subjects

All subjects in the experiment were seventh grade boys in a Philadelphia junior high school. Mean I.Q. score for the group was 113.76 with a standard deviation of 14.04.* Mean age for the group in months was 148.28 (approximately 12 years and 4 months) with a standard deviation of 6.35. Students were randomly selected from the homeroom rolls of seventh grade classes in the school. In order to keep the attrition rate to a minimum, the names of a few students with a history of excessive absences were crossed off prior to the selection of subjects.

## Procedures

Experimental Day # 1

On the first experimental day 80 subjects were given a standard test on the pursuit rotor. This test consisted of eight trials of 15 seconds each. Each trial was separated by a 15-second rest period. Following each of the trials the "time-on-target" was recorded and

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*The I.Q. scores were established on the basis of the Philadelphia Mental Ability Test which was administered to all subjects when they were in the sixth grade, approximately one year prior to the time of the experiment.

the clock was reset prior to the next trial. The subject's score for the day was the mean time-on-target for the eight trials. Instructions for all subjects on the first experimental day were as follows:

> This apparatus is a pursuit rotor. When it is switched on it spins around in this (illustrate) direction, and this dot (point) spins around with it. First you take this stylus in your hand and hold it by the handle. You are not allowed to hold it by the metal part. The idea is that when the dot starts to spin you try to keep the end of the stylus in contact with it. You'll have to move your hand around and around as the dot moves. This may be a little hard to do at first but don't get discouraged because it seems strange to everyone at the beginning.
>
> The way the experiment works is that you will sit down in that chair and wait. When this red light goes on (illustrate) you should stand, pick up this stylus, and hold the end of it right over the dot. Then when the light goes off, and the dot starts spinning you will try to keep the end of the stylus in contact with it. Your score will be determined by how long you are able to keep in touch with the dot while it is spinning. It will spin for 15 seconds and then will stop. When it stops, you sit down in the chair and wait until the light goes on again. Do you get the idea? Okay, wait until the light goes on, then get ready to start.

Experimental Days Two Through Eight

Following the initial test day the 80 subjects were divided into four experimental groups. The groups were equated on the basis of performance scores on the first day. This was accomplished by organizing the subjects according to first day mean scores from highest to lowest and then alternately assigning them to the four groups. The groups were then assigned to different practice conditions which were followed for the seven-day training period. The practice schedule for each group was arranged as shown in Table 1. During the seven-day training period therefore, group PR-1 accumulated a total of

Table 1. Daily Practice Sch edules for the Pursuit-Rotor Groups

| Group | Daily Units of Practice | Sequence of Trials* |
|---|---|---|
| PR-1 | 8 overt trials-no mental trials | |
| PR-2 | 6 overt trials-2 mental trials | M-0-0-0-M-0-0-0 |
| PR-3 | 4 overt trials-4 mental trials | M-0-M-0-M-0-M-0 |
| PR-4 | 2 overt trials-6 mental trials | M-M-M-0-M-M-M-0 |

*"M" refers to a mental trial while "0" refers to an overt or physical trial. The order in which the trials were taken is shown.

fifty-six overt trials while group PR-2 had forty-two, group PR-3 twenty-eight, and group PR-4 fourteen such trials. It should be noted, however, that the groups spent the same amount of time in the experimental situation.

Mental Practice Instructions. As is shown in Table 1, Group PR-1 took part in overt trials only. No additional instructions were given to this group after the first experimental day. The remaining groups, PR-2, PR-3, and PR-4, followed a schedule which required both overt and mental trials. To elicit the desired mental rehearsal these groups were given the following verbal instructions* at the beginning of the second experimental day.

> Now that you know how this apparatus works, I'm going to have you take part in a special kind of practice. For part of the time you will perform just as you did yesterday, that is, to try to keep the end of the stylus on the dot as it spins around. Then at other times, you must imagine doing exactly the same

*Inasmuch as no specific mental practice technique has been established as superior, the verbal instructions used in this study were prepared on the basis of what seemed appropriate for this group and this task. This may not have been the most effective technique.

thing. During these imaginery practices the turntable will be covered so that you cannot see it. However, I will want you to imagine that you see it spinning at the same speed and that you are concentrating on keeping the stylus in contact with the dot. When the red light comes on you will stand up in the same way but do not pick up the stylus nor move your hand around.

Your first trial today is an imaginery practice. In doing this you should concentrate as if you were really performing. In your mind, you will try to keep the stylus exactly on the dot in the same way. Remember, when the red light comes on you will stand and get ready to concentrate. Are you ready? When the light goes off you will start and when the turntable stops you will stop.

The apparatus made a soft whirring sound when revolving so that the subject knew if it was moving or stationary.

When the subject was scheduled for an overt trial the following instructions were given.

The next trial will be the same as those you did yesterday. That is, when the light goes on, you will stand, pick up the stylus and hold it over the dot, and when it starts to move you will try to keep in touch with it.

On each of the subsequent practice days, the following short reminder was given to each of the mental practice groups:

Today's schedule of practice will be exactly like yesterday's. Your first trial is an imaginery practice. Remember that you are to concentrate as hard as you can on keeping the stylus in contact with the dot. You know what it looks like when it spins around so just imagine that it is spinning and that you are keeping the stylus in touch with it.

Experimental Days Nine and Ten

On experimental days nine and ten all subjects were given eight overt trials. This is the same routine which was followed on the first day, and the same as group PR-1 performed throughout the training period. Experimental day nine was the test day and immediately followed the last

practice day. At this time the improvement made by the groups following different practice schedules was compared. Experimental day ten served as a retention check and followed the test day by three weeks. At this time the more permanent effects of the different practice schedules were compared.

## Analysis Of Data

### Comparison of Groups on Personal Data

Summary data for each of the groups are presented in Table 2. Group mean scores for both personal (I.Q. and age) and performance data are shown. Tables 3 and 4 present an analysis of the differences among the groups on the personal data. For the degrees of freedom

Table 2. Personal and Performance Data for Subjects in the Pursuit-Rotor Experiment

| | | I.Q. Scores | | Age (in months) | | Initial | | Test | | Retention | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Groups | N | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. |
| PR-1* | 20 | 107.55 | 11.72 | 148.00 | 5.67 | .27 | 0.23 | 4.37 | 1.66 | 4.16 | 2.00 |
| PR-2 | 20 | 112.00 | 12.67 | 146.95 | 7.96 | .27 | 0.22 | 4.43 | 1.53 | 4.54 | 1.80 |
| PR-3 | 20 | 119.30 | 16.90 | 148.80 | 5.72 | .27 | 0.23 | 3.98 | 1.24 | 3.91 | 1.34 |
| PR-4 | 20 | 116.20 | 14.86 | 149.35 | 6.05 | .27 | 0.22 | 2.94 | 1.26 | 3.18 | 1.30 |
| Group Means | | 113.76 | 14.04 | 148.28 | 6.35 | .27 | 0.23 | 3.93 | 1.42 | 3.95 | 1.61 |

*Group PR-1 (100% overt), PR-2 (75% overt - 25% mental), PR-3 (50% overt - 50% mental PR-4 (25% overt - 75% mental)

shown in the tables an F-ratio of 2.72 is required for significance at the 5 percent level. Neither of the F-values shown in these tables meets that level of significance. However, observation reveals that in I.Q. scores there was a tendency for the two groups assigned the greatest proportion of mental practice to be higher in intelligence.

Table 3. Analysis of Variance of I.Q. Differences Among the Pursuit-Rotor Groups

| Source | Sum of Squares | d.f. | Mean Square | F Ratio |
|---|---|---|---|---|
| Between Groups | 1566.14 | 3 | 522.05 | 2.60 |
| Within Groups | 15274.35 | 76 | 200.98 | |
| Total | 16840.49 | 79 | | |

Table 4. Analysis of Variance of Age Differences Among the Pursuit-Rotor Groups

| Source | Sum of Squares | d.f. | Mean Square | F Ratio |
|---|---|---|---|---|
| Between Groups | 65.25 | 3 | 21.75 | 0.53 |
| Within Groups | 3128.70 | 76 | 41.17 | |
| Total | 3193.95 | 79 | | |

Comparison of Initial Day Performance Scores

As can be observed in Table 2, the groups were so evenly matched on the basis of the initial test that a significant difference would not be expected. Table 5 includes the statistical comparison of the groups on initial day performance scores which verifies this lack of difference.

Table 5. Analysis of Variance of Initial Test Scores for the Pursuit-Rotor Groups

| Source | Sum of Squares | d.f. | Mean Square | F Ratio |
|---|---|---|---|---|
| Between Groups | 0.00 | 3 | 0.00 | 0.00 |
| Within Groups | 3.76 | 76 | 0.05 | |
| Total | 3.76 | 79 | | |

Comparison of Test Day Performance Scores

The test was administered to all groups after the seven-day practice period. By observing the means of the groups it was readily apparent that each group performed better on the test day than on the

initial day. Nevertheless, to determine whether the amount of improvement was significant, "t" tests were administered to compare the initial and test day means for each of the groups. A summary of these comparisons are included in Table 6. It can be seen that each of the

Table 6. Comparison of Initial and Test Means for the Pursuit-Rotor Groups

| Groups | Number | Initial Day Mean | Test Day Mean | Test Minus Initial | Standard Error | t-Values |
|---|---|---|---|---|---|---|
| PR-1 | 20 | .27 | 4.37 | 4.10 | .36 | 11.37* |
| PR-2 | 20 | .27 | 4.43 | 4.16 | .34 | 12.11* |
| PR-3 | 20 | .27 | 3.98 | 3.71 | .29 | 12.95* |
| PR-4 | 20 | .27 | 2.94 | 2.67 | .26 | 10.46* |

*Significant at the 5 percent level.

t-values is significant at the 5 percent level, indicating that all groups made a significant gain during the experimental period.

After having determined that the groups were not significantly different at the beginning of the experiment, and that all groups had improved during the training period, comparisons were again made on the test day to determine whether they had improved similarly. Table 7 includes this analysis. The F ratio of 4.63 indicates that there

Table 7. Analysis of Variance of Test Scores for the Pursuit-Rotor Groups

| Source | Sum of Squares | d.f. | Mean Square | F Ratio |
|---|---|---|---|---|
| Between Groups | 28.52 | 3 | 9.51 | 4.63* |
| Within Groups | 155.96 | 76 | 2.05 | |
| Total | 184.47 | 79 | | |

*Significant at the 5 percent level.

was a difference among the groups which was significant at the 5 percent level. By referring to Table 2 it can be observed that group

PR-2 had the highest score, followed in order by groups PR-1, PR-3, and PR-4. The significant F ratio at the test time immediately raises the question of exactly where the differences exist, i.e. between which groups. Duncan's Multiple Comparison Test (4) was administered to make this determination. This analysis was completed by the following computation:

1. $S\bar{x} = (\frac{2.05}{20})^{\frac{1}{2}} = .32$ with 76 d.f.

2. From Duncan's Significant Range Table with 60 (76) d.f. at 5 percent level

| No. of Means | 2 | 3 | 4 |
|---|---|---|---|
| Multipliers | 2.828 | 3.112 | 3.358 |
| .32 x Multiplier | .90 | 1.00 | 1.07 |

3. Group means are compared thusly:

| PR-1 | PR-2 | PR-3 | PR-4 |
|---|---|---|---|
| 4.37 | 4.43 | 3.98 | 2.94 |

It can be noted from this analysis that the differences among the means of PR-1, PR-2, and PR-3 are not of sufficient size to reach significance at the 5 percent level. However, groups PR-1 and PR-2 were found to be significantly higher than was group PR-4. Group PR-3 narrowly missed reaching the level required for significance over group PR-4.

Comparison of Retention Day Performance Scores

After a three week period of no practice all groups were given another test which was similar to those administered on the initial day and the test day. This final test was administered to determine the amount of retention and whether or not changes had appeared in the relative skill levels of the four groups. It can be noted from the mean scores in Table 2 that the differences among the groups

lessened. Also, there were slight fluctuations in performance when retention scores are compared with test scores, but the relative position of the groups remain the same. To analyze the significance of these fluctuations among the groups an analysis of covariance was administered to the retention day scores with test day scores used as the covariate. This analysis is shown in Table 7a. The F ratio of .72 indicates that the retention characteristics of the four schedules does not differ significantly.

Table 7a. Analysis of Covariance of Retention Day Scores When Adjusted for Test Day Scores

| Source | d.f. | yy | SS-Due | SS-About | d.f. | Mean Square | F Rat |
|---|---|---|---|---|---|---|---|
| Treatment Between | 3 | 19.69 | | | | | .72 |
| Error Within | 76 | 203.84 | 140.53 | 63.31 | 75 | .84 | |
| Treatment & Error Total | 79 | 223.53 | 158.39 | 65.14 | 78 | | |
| Difference for Testing Adjusted Treatment Means | | | | 1.83 | 3 | .61 | |

Correlation of I.Q. Scores and Performance

Because of the relatively large (though insignificant) F ratio on I.Q. differences among the groups, further investigation of I.Q. as a factor in the results seemed warranted. I.Q. scores were, therefore, correlated with performance scores at each of the test points in the experiment. Table 8 reveals the correlations for each of the groups and for the combination of groups. According to the Wallace and Snedecor (16) tables, r's become significant (5 percent level) at .43 when there are 19 degrees of freedom and at .22 with 76 degrees of freedom. With these standards, only one individual group correlation attained the level required for significance. Because of

Table 8. Relationship of I.Q. Scores to Pursuit-Rotor Performance Measures

| Group | d.f. | Initial Day Scores | Test Day Scores | Retention Day Scores | Improvement Score (Final Minus Initial) |
|---|---|---|---|---|---|
| PR-1 I.Q. Scores | 19 | -.17 | -.07 | -.03 | -.05 |
| PR-2 I.Q. Scores | 19 | -.21 | .37 | .28 | .40 |
| PR-3 I.Q. Scores | 19 | -.53* | .16 | .24 | .24 |
| PR-4 I.Q. Scores | 19 | -.09 | -.16 | .03 | -.16 |
| All Subjects | 76 | -.25* | .00 | .07 | .04 |

*Significant at the 5 percent level.

the relatively low level of this correlation, and since it occurred only at the initial test, it may be assumed that group intelligence differences did not greatly influence the outcomes of this study.

## Findings on Experiment #1

In the experiment involving pursuit rotor performance it was determined that:

(1) All groups improved significantly during the experimental period.

(2) There were no significant differences in the amount of improvement shown by group PR-1 (100% physical practice), group PR-2 (75% physical and 25% mental practice) and group PR-3 (50% physical and 50% mental practice) during the experimental period.

(3) Group PR-4 (25% physical and 75% mental practice) improved less than did groups PR-1 or PR-2 during the experimental period.

(4) I.Q. scores did not correlate consistently with performance scores at any time during the experimental period, nor with the amount of improvement made.

## EXPERIMENT # 2 (SOCCER KICK)

### The Task

The learning task for the second experiment was a soccer kick for accuracy with the non-preferred foot. Such a kicking task was selected because it is a gross motor movement and the sequence of responses is similar to that of several regular sports skills. The applicability of the findings to common skills should therefore be rather general. The non-preferred foot was selected in order to add to the novelty of the task and thus facilitate greater improvement during the experimental period. In addition, the particular nature of the activity was such that unauthorized practice during the experimental period was unlikely.

A remedial gymnasium facility was used for the soccer kicking activity. Only one subject was allowed into the room at a time, so that no one was able to observe another in practices or tests. The task required the subject to kick a soccer ball against a wall so that it would rebound into a target area. He stood behind a soccer ball which was placed on a one-inch high tee and 13 feet from the wall. The tee was used so that the ball could more easily be kicked into the air and against the wall. The target area was made up of 16 concentric circles, the center one being the area from which the ball was kicked. This center circle had a radius of nine inches and each of the remaining 15 circles was nine inches apart. The radius of the target area was therefore 144 inches. The center circle was given a point value of 16, the next-to-the-center circle 15, and

down to 1 point for the outside circle. Kicked balls rebounding off the wall and into a particular circle scored the point value of that circle for the kicker. The wall against which the ball was kicked, was of solid brick construction. No target or mark was put on the wall, but the perfectly kicked ball usually hit the wall about four feet from the floor. The ceiling was of sufficient height (16 feet) so that none of the kicked balls reached it.

A leather soccer ball inflated to eight pounds of pressure was used. The relatively low pressure was selected so that the subject could kick the ball reasonably hard without it flying too easily out of the target area. All subjects wore sneakers during the performance of the task. For any who forgot their own sneakers during a practice or test day, six pairs in various size were provided at the test area.

Subjects

All subjects in this experiment were seventh grade boys in a Philadelphia junior high school. (The school was not the same as the one used for the Pursuit Rotor experiment.) Mean I.Q. score for the group was 95.28 with a standard deviation of 16.82. Mean age for the group in months was 150.78 (approximately 12 years 7 months) with a standard deviation of 5.27. Students were randomly selected from the homeroom rolls of most of the seventh grade classes in the school. In order to keep the attrition rate to a minimum, the names of a few students with a history of excessive absences were crossed off prior to the selection of subjects.

## Procedure

### Experimental Day # 1

On the first experimental day 72 subjects were given a common test on the soccer kicking task. This test consisted of having each subject take 12 kicks with the non-preferred foot. The subject's score for this test was the mean point value for the 12 kicks (the accumulative score divided by 12).

In order to determine the subject's non-preferred foot, they were asked to step up to the starting point and take three practice kicks with their "kicking" foot. The following initial instructions were given:

> In this experiment I'm going to have you practice kicking a soccer ball. The idea is to step up to the ball and kick it into the air and against the wall so that it will bounce back into the target area. You should try to kick it in a straight line, and just hard enough so that it will rebound into the center circle. Your score will depend on how close you get to the center circle. To get the idea of how to do this, step up here and kick it with your kicking foot to see how close you can get to the center.

If the subject made all three kicks with the same foot, the opposite foot was then selected as the non-preferred foot. If during the three practice trials the subject alternated feet, he was asked to kick a few more until a clear preference was established.

After the non-preferred foot had been established the following instructions were given:

> I want you to try this with your left* foot.

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*The terms "right" and "left" as used in this description were reversed in cases where the right foot had been established as the non-preferred foot.

This will probably seem a little strange at the beginning. However, the idea is to stand back one step from the ball, take a quick step and kick the ball with the left foot. You should pick out a spot on the ball and watch that spot right up until the toe hits the ball; like this (demonstration). Come over here and take a few practice tries.

I'm going to give you twelve kicks and I will keep score. Keep in mind that you should stand one long step behind the ball and slightly to the right side. Before moving, pick out a spot on the ball where the toe should hit when you kick it. This spot should be in the center of the ball but in the lower part. You begin by leaning forward slowly and then taking a hopping step with the right foot. The right foot should land a few inches to the right of the ball and slightly to the rear. At the same time the left foot is ready to swing forward and kick the ball by striking it at exactly the spot on the ball that you have picked out. It is important that you watch the spot until the toe actually hits the ball. Try to kick the ball straight, and hard enough so that it will bounce back near the center of this target area.

Twelve kicks were then administered for score. Some of the more obvious problems were corrected during this period.

Experimental Days Two Through Eight

Following the initial test day the 72 subjects were divided into four experimental groups. The groups were equated on the basis of first day performance scores by essentially the same technique as was used in Experiment # 1. Practice schedules for experimental days two through eight were arranged as shown in Table 9. During the seven day training period group S-1 had a total of eighty-four overt kicks, group S-2

63 kicks, group S-3 42 kicks and group S-4 21 kicks. The different groups, however, spent approximately the same amount of time at the experimental station.

Table 9. Daily Practice Schedules for the Soccer Groups

| Group | Daily Units of Practice | Sequence of Trials* |
|---|---|---|
| S-1 | 12 kicks - no mental trials | |
| S-2 | 9 kicks - 3 mental trials | M-O-O-O (repeat 3 times) |
| S-3 | 6 kicks - 6 mental trials | M-O (repeat 6 times) |
| S-4 | 3 kicks - 9 mental trials | M-M-M-O (repeat 3 times) |

*"M" refers to a mental trial or an imaginery kick while "O" refers to an overt trial or an actual kick. The order in which the trials were taken is shown.

Mental Practice Instructions. Groups S-2, S-3 and S-4 followed schedules which required both physical and mental practice. On the second experimental day the verbal instructions used to elicit the proper mental practice were as follows:

> Now that you know how to do this skill, I'm going to have you take part in a special kind of practice. Part of the time you will kick the ball just as you did yesterday. Then at other times you must imagine kicking the ball in exactly the same way. During the imaginery kicks you will go up to the starting place behind the ball and concentrate on making a perfect kick. When you do this, however, you will not be allowed to move.
>
> Your first kick today will be an imaginery kick. When you do this I want you to stand at your starting point behind the ball, pick out the spot on the ball that you should kick, then imagine that you slowly lean forward and take the step with the right foot. The left foot then swings forward and the toe hits the ball right at the spot that you are watching. Kick the ball straight and hard enough so that it will bounce back near the center of the target

area. Try to actually <u>feel</u> yourself doing this without moving your body. Do you get the idea?

Okay, step up to the starting spot and go through this imaginery practice. As soon as you have finished it let me know.

When the subject was scheduled for an overt trial (a kick) the following instructions were given:

Your next practice will be a real kick just as you did yesterday. As soon as you are ready, step right up and kick the ball.

On each of the subsequent practice days the following reminder was given to each of the mental practice groups:

Today's practice schedule will be exactly like yesterday's. Your first trial will be an imaginery kick. Remember that you are to concentrate as hard as you can on doing everything right when you kick the ball. <u>Feel</u> yourself going through the movements smoothly and kicking the ball in exactly the right spot. When you are ready, step up to the starting spot and take the imaginery kick. Let me know when you have finished this.

<u>Experimental Days Nine and Ten</u>

On experimental days nine and ten all subjects were administered a test involving twelve kicks. This test was similar to the one which was given all groups on the first experimental day, and the same as the daily routine followed by group S-1 throughout the training period. Experimental day nine served as the test day and immediately followed the last day of the training period. Experimental day ten followed the test day by three weeks and was used to check the more permanent effects of the different schedules.

## Analysis of Data

### Comparison of Groups on Personal Data

Summary data for all groups on personal measures and performance scores are shown in Table 10. These data are analyzed for statistical

Table 10. Personal and Performance Data for Subjects in All Soccer Groups

| | | Subjects | | | | Performance Scores | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | I.Q. | | Age | | Initial | | Test | | Retention | |
| Groups | N | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. |
| S-1* | 18 | 95.44 | 13.51 | 148.56 | 3.99 | 5.90 | 3.40 | 9.22 | 2.18 | 8.39 | 2.81 |
| S-2 | 18 | 92.28 | 11.78 | 150.72 | 4.39 | 5.99 | 2.44 | 9.22 | 2.51 | 8.51 | 2.40 |
| S-3 | 18 | 103.94 | 31.38 | 153.22 | 6.23 | 6.44 | 2.10 | 8.87 | 2.18 | 8.97 | 2.95 |
| S-4 | 18 | 89.44 | 10.62 | 150.61 | 6.48 | 6.13 | 2.57 | 9.37 | 1.41 | 9.57 | 2.25 |
| Group Means | | 95.28 | 16.82 | 150.78 | 5.27 | 6.12 | 2.63 | 9.17 | 2.06 | 8.86 | 2.63 |

*Group S-1 (100% overt), S-2 (75% overt - 25% mental), S-3 (50% overt - 50% mental), S-4 (25% overt - 75% mental)

differences in Tables 11 through 16. Tables 11 and 12 include an analysis of the differences among the groups on the personal measures that were available, i.e. I.Q. scores and ages. For the degrees of freedom shown in these tables an F ratio of 2.74 must be attained for

Table 11. Analysis of Variance of I.Q. Differences Among the Four Soccer Groups

| | Sum of Squares | d.f. | Mean Square | F Ratio |
|---|---|---|---|---|
| Between Groups | 2127.00 | 3 | 709.00 | 2.00 |
| Within Groups | 24119.44 | 68 | 354.70 | |
| Total | 26246.44 | 71 | | |

Table 12. Analysis of Variance of Age Differences Among the Four Soccer Groups

| | Sum of Squares | d.f. | Mean Square | F Ratio |
|---|---|---|---|---|
| Between Groups | 197.00 | 3 | 65.67 | 2.26 |
| Within Groups | 1971.44 | 68 | 28.99 | |
| Total | 2168.44 | 71 | | |

significance at the 5 percent level. Neither of the analyses meets this standard, thus indicating no significant difference between the groups on I.Q. scores nor ages.

Comparison of Initial Day Performance Scores

Table 13 includes the statistical comparison of groups on initial day performance scores. The F ratio of .14 does not closely approach the level of 2.74 required for significance. This indicates

Table 13. Analysis of Variance of Initial Scores for the Four Soccer Groups

| | Sum of Squares | d.f. | Mean Square | F Ratio |
|---|---|---|---|---|
| Between Groups | 3.01 | 3 | 1.00 | .14 |
| Within Groups | 484.91 | 68 | 7.13 | |
| Total | 487.92 | 71 | | |

that there were no significant differences among the four groups at the beginning of the experimental period.

Comparison of Test Day Performance Scores

After the seven day practice period a test was administered to all groups to determine (1) if they had improved significantly and (2) if there were any differences among the groups in performance

level at that time. Table 14 includes a comparison of the initial and test day means of all groups. With 18 degrees of freedom,

Table 14. Comparison of Initial and Test Means for the Soccer Groups

| Groups | N | Initial Day | Test Day | Test Minus Initial | Standard Error | t-Values |
|---|---|---|---|---|---|---|
| S-1 | 18 | 5.90 | 9.22 | 3.32 | .66 | 5.03* |
| S-2 | 18 | 5.99 | 9.22 | 3.23 | .68 | 4.75* |
| S-3 | 18 | 6.44 | 8.87 | 2.43 | .48 | 5.06* |
| S-4 | 18 | 6.13 | 9.37 | 3.24 | .61 | 5.31* |

*Significant at the 5 percent level.

t-values become significant at 2.10 (for the 5 percent level). As can be noted by the means and the t-values, all groups improved significantly from the initial day to the test day.

After it had been established that there was no significant difference among the groups on the initial day, and that all groups had improved during the training period, group scores on the test day were compared to determine whether all groups improved similarly. Table 15 includes these comparisons. The size of the F ratio in this

Table 15. Analysis of Variance of Test Scores for the Four Soccer Groups

| | Sum of Squares | d.f. | Mean Square | F Ratio |
|---|---|---|---|---|
| Between Groups | 2.44 | 3 | .81 | .18 |
| Within Groups | 302.24 | 68 | 4.44 | |
| Total | 304.68 | 71 | | |

analysis does not reach the level of significance. This means that

the different training programs resulted in approximately equal amounts of improvement.

Comparison of Retention Day Performance Scores

After a three week period of no practice all groups were given another test which was similar to that administered on the initial day and the test day. This final test was used to determine the general level of retention of the groups and also if there were characteristics of the training program which might become evident after such a no-practice period. Table 10 reveals a slight reduction in the overall proficiency of the groups from the test day to the retention day. It can be noted that the two groups with the greatest proportion of overt practice exhibited a reduction in

Table 16. Analysis of Covariance of Soccer Retention Scores When Adjusted for Test Scores

| Source | d.f. | yy | SS-Due | SS-About | d.f. | Mean Square | F Ratio |
|---|---|---|---|---|---|---|---|
| Treatment Between | 3 | 15.55 | | | | | 1.25 |
| Error Within | 68 | 466.52 | 196.43 | 270.09 | 67 | 4.03 | |
| Treatment and Error | 71 | 482.07 | 196.81 | 285.26 | 70 | | |
| Difference for Testing Adjusted Treatment Means | | | | 15.18 | 3 | 5.06 | |

performance while the two groups with a greater proportion of mental practice showed slight increases. Table 16 includes an analysis of covariance designed to analyze these fluctuations among the groups. The F-value of 1.25 is not significant, indicating no substantial differences in the amount of retention.

Correlation of I.Q. Scores and Kicking Performance

Of some interest in this study was the possible relationship between intelligence and performance in the soccer kick. Table 17 includes comparisons which were made between I.Q. scores and initial performance scores, test performance after the training period, and retention scores. No significant correlations are noted for the group

Table 17. Relationship of I.Q. Scores to Soccer Performance Scores

| Group | d.f. | Initial Day Performance Scores | Test Day Performance Scores | Retention Day Performance Scores | Improvement Scores (Test Minus Initial) |
|---|---|---|---|---|---|
| S-1 I.Q. Scores | 17 | -.25 | -.12 | -.18 | .21 |
| S-2 I.Q. Scores | 17 | -.39 | .21 | -.29 | .51* |
| S-3 I.Q. Scores | 17 | .10 | .19 | .14 | .10 |
| S-4 I.Q. Scores | 17 | -.26 | -.04 | -.01 | .23 |
| All Subjects | 68 | -.09 | .07 | -.02 | .15 |

*Significant at the 5 percent level.

as a whole. However, a low positive correlation was found between I.Q. scores and the amount of improvement shown by subjects in group S-2.

## FINDINGS

In the experiment involving the soccer kick it was determined that:

(1) All groups improved significantly during the experimental period.

(2) All groups made similar improvement during the seven-day training period.

(3) The retentiveness of the groups over a three-week no-practice period did not significantly vary according to the practice schedule which had been followed.

(4) I.Q. scores did not correlate consistantly with performance scores at any time during the experimental period, nor with the amount of improvement made.

## EXPERIMENT # 3 (JUMP SHOT)

### The Task

The task for the third experiment was a modified basketball jump shot. Several variations from the traditional jump shot were made in order to offer greater experimental controls while still using a rather typical kind of motor response. An 8½ inch playground ball was used, which was smaller and lighter than the regulation basketball. A regulation basket and net were used but it was lowered to a nine foot height rather than the ten feet used in regulation basketball. The jump shot was made from a distance 10 feet from the goal.

No backboard was used with the basket which was instead attached directly to a pole standard.* This arrangement was used to add to the novelty of the task and to prevent any "lucky" goals which could result from a rebound off a backboard. The experimental room had a ceiling of 18 feet so there was no problem with the ball striking any object during an attempted shot. Only the experimentor and subject were in the room during the practice and test sessions.

### Subjects

The subjects in this experiment were seventh grade boys in a Philadelphia junior high school. (The school was different from either of those used for experiments # 1 or # 2.) Mean I.Q. scores for the group was 108.64 with a standard deviation of 8.72. Mean age for the subjects was 146.38 months (approximately 12 years and 7 months) with a standard

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*The apparatus used was the Scoremaster Portable Basketball Standard manufactured by the Jayfro Athletic Supply Company, Inc., Groton, Connecticut.

deviation of 4.59. Students were randomly selected from the homeroom rolls of most of the seventh grade classes in the school. In order to keep the attrition rate to a minimum, the names of a few students with a history of excessive absences were crossed off prior to the selection of subjects.

## Procedures

### Experimental Day # 1

On the first experimental day 60 subjects were given instructions and an initial test on the jump shooting task. In this test each subject took 12 shots. In order to establish a more discriminating measure of shooting skill three points were given for a successful goal, one point for a ball touching the rim but failing to go in, and no points if the ball missed both. The subject's score for the day was the accumulative point totals for all shots.

The following instructions were given to all subjects on the first day:

> In this experiment I will have you shooting a basketball jump shot. It is a little different from a regular basketball shot because this ball is smaller and the basket is a different height. Now, I want you to stand in this box (a 3' x 3' square drawn on the floor) with the ball. Place it in your hands in this manner (demonstration) with the right hand* behind the ball and the left hand along the side. When shooting the ball, lift it directly over the eyes and push it so that it rolls off the ends of the fingers, like this

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*If it had been established earlier (while completing a short questionaire) that the subject was left handed the left hand was used in this description.

(demonstration). Try shooting two or three to me in this manner. Push it with the right hand so that it rolls off the fingers and spins backward toward you. (Three such shots were taken by the subject).

Now I want you to jump off the floor and shoot in the same way while you are in the air. Jump high and at the same time bring the ball up just over your eyes, like this(demonstration). Try shooting it to me in this way. (Three jump shots from subject to experimentor.) Now, face the basket and do everything the same way except that now you will try to make a goal. Focus your eyes on the part of the rim that is closest to you and try to push the ball just over that spot. Take a few practice shots. (Subject was given three tries during which additional corrections were made as warranted.)

Now I'm going to have you take 12 shots and I will keep your score on these. So do your best to make a goal on every shot. Are you ready? Okay, begin.

Subjects were then given 12 shots at their own pace. The experimentor retrieved the ball and tossed it back to them.

Experimental Days Two Through Eight

Following the initial day the 60 subjects were divided into four experimental groups. The groups were equated on the basis of first day performance scores by the same techniques used in experiments # 1 and # 2. Practice schedules for experimental days two through eight were arranged as shown in Table 18.

Table 18. Daily Practice Schedules for the Four Jump Shot Groups

| Group | Daily Units of Practice | Sequence of Trials* |
|---|---|---|
| J-1 | 12 shots - no mental trials | |
| J-2 | 9 shots - 3 mental trials | M-O-O-O- (repeat 3 times) |
| J-3 | 6 shots - 6 mental trials | M-O (repeat 6 times) |
| J-4 | 3 shots - 9 mental trials | M-M-M-O (repeat 3 times) |

*"M" refers to a mental trial or an imaginery shot while "O" refers to an overt trial or an actual shot. The order in which the trial was taken is shown.

During the seven day training period group J-1 had a total of 84 shots, group J-2 63 shots, group J-3 42 shots and group J-4 21 shots.

Mental Practice Instructions. Groups J-2, J-3, and J-4 all had mental practice as a part of their program. The following verbal instructions were given on the first practice day to elicit the desired mental rehearsal.

> Now that you know how to do the jump shot, I'm going to have you take part in a special kind of practice. Today you will again take twelve shots. Some of the shots will be just as you did yesterday. Then at other times I will have you imagine shooting a jump shot in the same way. During this imaginery shot you will stand in the starting box, look at the basket, and concentrate on shooting the ball properly. When you do this, however, you will not have the ball and you will not be allowed to move.
>
> Your first shot today will be an imaginery shot. To do this I want you to think your way through the shot, that is, imagine what it feels like to shoot the ball properly. Remember that you place your right hand behind the ball and the left hand out to the side. Then you jump into the air and at the same time bring the ball up just over the eyes. When you reach the top of your jump you push the ball with the right hand so that the ball rolls off the end of the fingers. Keep your eyes on the closest part of the rim and try to push the ball just hard enough so that it goes over the rim and into basket. Try to actually feel yourself doing this without moving your body. Do you get the idea?
>
> Okay, now move into the starting box and go through the imaginery practice. As soon as you have completed it, let me know.

On each subsequent day the following reminder was given to all mental practice groups:

> Today's practice will be exactly like yesterday's. Your first try will be an imaginery shot. Remember that you are to concentrate on jumping, watching the rim, and pushing the ball off the end of the fingers so that it goes just over the rim

and into the basket. Try to feel yourself going through a perfect shot. Step into the starting box and go through with the imaginery shot. When you have completed it, let me know.

Experimental Days Nine and Ten

Consistent with Experiments # 1 and # 2, experimental days nine and ten followed the same test schedule as on the initial day, i.e. all groups were given 12 shots for score. Experimental day nine immediately followed the last practice day, while experimental day ten was three weeks later.

## Analysis of Data

### Comparison of Groups on Personal Data

Summary data for all groups on personal measures and performance scores are shown in Table 19. These data are analyzed for differences

Table 19. Personal and Performance Data for Subjects in all Jump Shot Groups.

| | | Subjects | | | | Performance Scores | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | I.Q. | | Age | | Initial | | Test | | Retention | |
| Groups | N | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. |
| J-1* | 15 | 106.33 | 9.85 | 147.47 | 4.91 | .74 | .37 | 1.13 | .51 | 1.03 | .36 |
| J-2 | 15 | 109.73 | 9.82 | 146.13 | 4.94 | .83 | .35 | .90 | .39 | 1.18 | .45 |
| J-3 | 15 | 109.60 | 8.79 | 146.33 | 3.73 | .83 | .38 | .79 | .41 | .90 | .35 |
| J-4 | 15 | 108.87 | 6.42 | 145.60 | 4.79 | .77 | .35 | .93 | .42 | 1.02 | .46 |
| Group Means | | 108.64 | 8.72 | 146.38 | 4.59 | .79 | .36 | .94 | .43 | 1.03 | .41 |

*Group J-1 (100% overt), J-2 (75% overt - 25% mental), J-3 (50% overt - 50% mental), J-4 (25% overt - 75% mental)

between groups in Tables 20 through 25. Tables 20 and 21 include an analysis of the differences between groups on I.Q. scores and ages.

Table 20. An Analysis of Variance of the I.Q. Scores for the Jump Shot Groups.

| | Sum of Squares | d.f. | Mean Square | F Ratio |
|---|---|---|---|---|
| Between Groups | 112.33 | 3 | 37.44 | .48 |
| Within Groups | 4367.60 | 56 | 77.99 | |
| Total | 4479.93 | 59 | | |

Table 21. An Analysis of Variance of the Ages of the Jump Shot Groups.

| | Sum of Squares | d.f. | Mean Square | F Ratio |
|---|---|---|---|---|
| Between Groups | 27.78 | 3 | 9.26 | .43 |
| Within Groups | 1196.40 | 56 | 21.36 | |
| Total | 1224.18 | 59 | | |

For the degrees of freedom indicated, F ratios become significant at 2.76. As can be noted neither F reaches that size, thus indicating that the groups were not significantly different on these personal data.

Comparison of Initial Day Performance Scores

Table 22 includes a statistical analysis of the groups on initial day performance scores. The F ratio does not reach the

Table 22. Analysis of Variance of Initial Day Performance for the Jump Shot Groups.

| | Sum of Squares | d.f. | Mean Square | F Ratio |
|---|---|---|---|---|
| Between Groups | .95 | 3 | .32 | .74 |
| Within Groups | 23.86 | 56 | .43 | |
| Total | 24.81 | 59 | | |

level required for significance, indicating that there are no greater differences among the groups in performance level than would have been expected by chance.

Comparison of Test Day Performance Scores

After seven days of practice a test was administered to all groups. This test, which was identical to that given on the initial day, was used (1) to determine if the groups had improved significantly and (2) if there was any difference between the groups. Table 23 shows a comparison of mean group improvement from the initial day to the test day. Since t ratios become significant at 2.13, only group J-1

Table 23. Comparison of Initial and Test Day Means for the Jump Shot Groups.

| Groups | N | Initial Day | Test Day | Test Minus Initial | Standard Error | t Ratios |
|---|---|---|---|---|---|---|
| J-1 | 15 | .74 | 1.13 | .39 | .14 | 2.79* |
| J-2 | 15 | .83 | .90 | .07 | .10 | .70 |
| J-3 | 15 | .83 | .79 | -.04 | .12 | .33 |
| J-4 | 15 | .77 | .93 | .16 | .9 | 1.78 |

*Significant at the 5 percent level.

reached the level of significance. It can be noted, therefore, that the groups as a whole did not make large improvements during the training period. It appeared to this investigator that either (1) the initial instructional program was insufficient to get the students started on the proper techniques, or (2) the task was generally not within the ability range of the subjects.

Groups were compared by analysis of variance on test day scores

to determine if significant differences had developed among the groups during the training period. This analysis is shown in Table 24. The t value for significance (2.78 for the 5 percent level) is not reached. Thus the differences among the groups are not greater than would be expected by chance.

Table 24. Analysis of Variance of Test Day Scores for the Jump Shot Groups.

| | Sum of Squares | d.f. | Mean Square | F Ratio |
|---|---|---|---|---|
| Between Groups | .92 | 3 | .31 | 1.61 |
| Within Groups | 10.69 | 56 | .19 | |
| Total | 11.61 | 59 | | |

Comparison of Retention Day Performance Scores

Table 25 includes an analysis of changes in proficiency level among the groups at the time of the retention check. These data were collected three weeks after the test day. Inasmuch as the differences among the means were lessened from test day comparisons no significant differences would be expexted at this time. However, an analysis of covariance was computed with the retention data, using test day scores as the covariant, to determine the significance of the fluctuations. Table 19 reveals that all groups except J-1 showed gains over the test day. The rank order of the groups changed from test day to retention day in that group J-2 exhibited greater skill at the latter time. Nevertheless, the fluctuations among groups were not great enough to reach statistical significance.

It should be noted that the superior proficiency on the part of group J-1 on the test day was not reflected at the retention check. In fact, the level of proficiency of this group at retention corresponds with the mean of the combined groups. When overall learning and retention are considered,

Table 25. Analysis of Covariance of Jump Shot Scores When Adjusted for Test Scores.

| Source | d.f. | yy | SS-Due | SS-About | d.f. | Mean Square | F Ratio |
|---|---|---|---|---|---|---|---|
| Treatment Between | 3 | .60 | | | | | 1.47 |
| Error Within | 56 | 9.42 | 2.06 | 7.35 | 55 | .13 | |
| Treatment & Error | 59 | 10.01 | 2.07 | 7.94 | 58 | | |
| Difference for Testing Adjusted Means | | | | .59 | 3 | .20 | |

therefore, it cannot be assumed that the schedule followed by this group (100% physical practice) is superior to the others.

Correlation of I.Q. Scores and Jump Shot Performance

As in the other experimenta, I.Q. scores were correlated with performance scores on the three tests during the experiment. These correlations are shown in Table 26. Although two r's reach the level

Table 26. Relationship of I.Q. Scores to Jump Shot Performance Scores

| Group I.Q. Scores | d.f. | Initial Day Performance Scores | Test Day Performance Scores | Retention Performance Scores | Improvement Scores (Test Minus Initial) |
|---|---|---|---|---|---|
| J-1 | 14 | .03 | -.04 | .26 | -.06 |
| J-2 | 14 | -.44 | .10 | -.11 | .57* |
| J-3 | 14 | -.12 | -.14 | -.21 | -.03 |
| J-4 | 14 | -.55* | -.53 | -.46 | -.09 |
| All Subjects | 56 | -.25 | -.15 | -.10 | .15 |

* Significant at the 5 percent level.

required for significance at the 5 percent level these correlations are not apparent in the other groups nor in the correlations for all subjects as a whole.

## FINDINGS

(1) Only slight improvement was made by the groups as a whole during the experimental period. The group following the 100 percent physical practice schedule (J-1) made a significant improvement during this period. The slight advantage of this group, however, was nonexistent after a three-week no-practice period.

(2) The overall learning or retention rate of this task did not appear to be a factor of the proportion of physical and mental practice in the schedule.

(3) The jump shot appeared to be too complex a task for the rapid learning of the subjects in this study.

(4) I.Q. scores did not correlate consistantly with performance scores at any time during the experimental period, nor with the amount of improvement made.

## REACTION OF SUBJECTS TO MENTAL PRACTICE INSTRUCTIONS

Although the primary purpose of this study was to determine the effect of the mental practice on subsequent performance, some interest also existed in the overt behavior of the subjects during these sessions, and their reactions to them. Inasmuch as the mental process is not actually observed, one cannot be certain exactly how the subject is rehearsing the task, or the intensity of his concentration. However, certain overt responses were readily apparent. The type of behavior did not appear to be peculiar to the particular task. Consequently the responses will be discussed as a total group rather than according to the particular task being learned.

It seemed clear that formalized mental practice in the manner solicited in this study was a new experience for most of the subjects. This was reflected in the quizical reactions to the initial verbal suggestions, and also their comments at the conclusion of the experiment. Nevertheless, there was a ready willingness on the part of almost all subjects to cooperate conscientiously in this type of experience.

The overt behavior of the subjects during mental practice may be categorized into three general areas: (1) visual responses, (2) postures assumed, and (3) movements of the body. Perhaps the one with the greatest diversity has to do with visual behavior. Many subjects closed their eyes during the mental practice sessions, with some clinching the eyelids tightly as if to increase the concentration. Several held one of their hands over the eyes. The majority of subjects

stared in the direction of the apparatus or task to be performed. Some moved the eyes as if simulating a performance, i.e. around and around for the pursuit-rotor performance or following the flight of the ball in an imaginary jump shot or soccer kick. Still others stared at a blank wall or vaguely into the distance.

The posture of most subjects during mental practice was a general state of readiness for action. This was particularly true of the soccer kick and jump shot where the subjects most often leaned forware or leaned on one foot as if ready to jump and shoot or kick the ball. Most subjects let the arms hang down to the sides but some grasped the hands behind the back or put them in their pockets. During mental practices the total body was usually tense.

Even though subjects were told that they were not allowed to move during the mental practices some did engage in seemingly spontaneous movements. These involved swaying back and forth, swinging the arms slightly, flinching, or rolling the head around as if watching the pursuit rotor. No gross movements, or anything resembling the overt trial was permitted. In the jump shot and soccer kick the length of time consumed for a mental practice was usually the same as that for an overt trial. Three of four subjects, however, required exceptionally long periods for the mental practice.

The personal reaction of each subject to the mental practice was solicited after the last session. They almost universally expressed the belief that these practices helped them learn the skill. Some said that it was fun, "like a game". Others reported that it helped a great deal expecially in the beginning, that the task was easier

after mental practice, and that they thought about it at times other than the regular practice session. A few subjects reflected a somewhat negative reaction such as "They're OK but I liked the real practices better." Almost all negative comments come from subjects who had a predominance of mental practices during each session (group 4 from each experiment).

## CONCLUSIONS

(1) Given a specific amount of practice time, a schedule combining both physical and mental practice can prove as valuable in the learning of a motor task as a schedule in which the entire time is devoted to physical practice.

(2) Given a specific number of practice trials or repetitions, a schedule combining both overt and mental trials can prove as valuable in the learning of a motor task as a schedule in which all trials are overt.

(3) When a motor task is within the motor capacity level of the learner, up to fifty percent of the practice time (or trials) in mental practice can be as effective as one hundred percent of the time in physical practice.

(4) The proportion of time which might be profitably devoted to mental practice appears to be dependent upon the nature of the task, i.e. its complexity, familiarity, and whether the learner has the physical abilities to perform the activity.

(5) Within the intelligence ranges of subjects used in these studies, I.Q. scores are not indicative of one's ability to benefit from mental practice.

(6) The type of initial orientation and verbal cues used in these studies seem appropriate for the promotion of effective mental practice.

(7) Subjects such as those used in these studies respond favorably and conscientiously to the suggestion of mental rehearsal. However, when used to excess, i.e. up to three-fourths of the practice time, some students become impatient with this technique.

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